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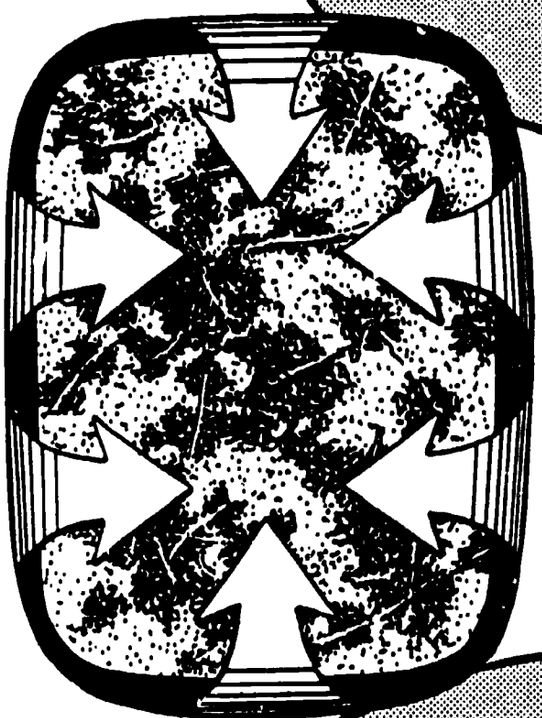
ABSTRACT

This instructor's guide contains materials needed for teaching a two-lesson unit on trickling filters. These materials include: (1) an overview of the two lessons; (2) lesson plans; (3) lecture outline (keyed to a set of slides accompanying the unit); (4) overhead transparency masters; (5) student worksheet (with answers); and (6) two copies of a final quiz (with and without answers). The first lesson (structure and theory) covers an introduction to trickling filters, components, modes of operation, and the microbiology of trickling filters (emphasizing the factors that affect growth). The second lesson covers the operation of trickling filters. The laboratory tests recommended for influent and effluent monitoring are presented and related to the factors affecting biomass growth. Calculations regarding loading, recirculation, and efficiency are presented and practiced. Plant observation and monitoring is discussed with an emphasis on awareness and identification of existing and potential problems. Finally, a number of operational problems are presented with recommended corrective measures. (JN)

Biological Treatment Process Control

Trickling Filters



Instructor's Guide

Linn-Benton Community College
Albany, Oregon
1984

BIOLOGICAL TREATMENT PROCESS CONTROL

TRICKLING FILTERS

INSTRUCTOR'S GUIDE

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TRICKLING FILTERS

INSTRUCTOR'S GUIDE

Table of Contents

TRICKLING FILTERS

Overview of Lessons

This unit on Trickling Filters is divided into two lessons. Lesson I - Structure and Theory - covers an Introduction to Trickling Filters, Components, Modes of Operation and the Microbiology of Trickling Filters. In this lesson we review the structural components of the filter and their purpose. Since this is an intermediate course the review might emphasize how the components affect operation. Operational modes are discussed with a look at which modes are applicable under different conditions. Finally, the microbiology of the filter is discussed. Emphasis here should be on the factors that affect growth.

Lesson II covers the Operation of Trickling Filters. The laboratory tests recommended for influent and effluent monitoring are presented and related to the factors affecting biomass growth. Calculations regarding loading, recirculation, and efficiency are presented and practiced. Plant observation and monitoring is discussed with an emphasis on awareness and identification of existing and potential problems. Finally, a number of operational problems are presented with corrective measures recommended.

Lesson Plans

Lesson I - Structure and Theory

- Have students read material ahead of time if possible.
- Lecture from outline with slide support.
- Add additional slides to emphasize areas of particular interest.
- Recommended length - 30 minutes.

Lesson II - Operation

- Again, assign reading ahead of time.
- Lecture from outline with slide support through Slide TF 2.17
- Move to overheads or chalkboard to explain calculations.
- Assign work sheet; allow 20-30 minutes to do problems; explain and correct problems.
- Return to outline and slides at TF 2.18.
- Assign Final Test.
- Recommended length - 60-75 minutes

Other Suggestions:

Demonstration items such as types of media, underdrain tiles, orifice nozzles, etc. can be used.

Set up a microscope to view organisms; have a fresh media rock with organisms on display.

Collect samples of raw, primary effluent, filter effluent, and secondary effluent in jars to display characteristics.

Have samples of trend chart for process indicator plotting.

TRICKLING FILTERS

LECTURE OUTLINE

LESSON I - STRUCTURE AND THEORY

TF 1.1 and 1.2	Title and Credit Slides
TF 1.3	Introduction to the Trickling Filter Process A Biological System Fixed Growth on Rocks Organics Stabilized as Liquids Passsed Down Through Growth
TF 1.4	Organization Slides This Lesson Looks at: Components Modes of Operation Microbiology
TF 1.5	Organization Slides First Look at Components and the Filters' Place in a Treatment System
TF 1.6	Components Media - Surface Area to Support Growth - Types of Material
TF 1.7	Components Distribution System - Rotary - Fixed
TF 1.8	Components Underdrain - Supports Media - Allows Air Circulation - Collects Waste Stream
TF 1.9	Components Ventilation - Forced - Natural
TF 1.10	The Trickling Filter System Relationship to Other Process Units

TF 1.11	Flow Pattern Liquid Flow Solids Flow Recirculation
TF 1.12	Pre-Filtration Importance and Affect of Filter Lowers BOD Loading Prevents Media and Orifice Clogging
TF 1.13	Post-Filtration Solids Separation
TF 1.14	Solids Handling
TF 1.15	Organization Slide Next Look at Modes of Operation
TF 1.16	Standard Rate Filters Hydraulic Loading Organic Loading Media Depth High Rate Filters Hydraulic Loading Organic Loading Media Depth Recirculation
TF 1.17	Roughing Filter Organic Loading
TF 1.18	Filter Staging Parallel Series
TF 1.19	Organization Slide Last Look at Microbiology
TF 1.20	Fixed Growth on the Media
TF 1.21	The Biomass The Types of Organisms Found

TF 1.22	Close-up of Growth on Media Relative Movement of: - Wastewater - Air (D.O.)
TF 1.23	Anaerobic and Aerobic Regions Diffusion of Nutrients, Wastes, and D.O. Nutrient Requirements
TF 1.24	The Sloughing Process Food and D.O. can no Longer Reach Bottom Layer
TF 1.25	Rate of Growth Effect of Food (BOD) and Temperature on Growth Rate
TF 1.26 - 1.29	Review Slides

LESSON II - OPERATION

TF 2.1 - 2.2	Title and Credit Slides
TF 2.3	Review of the Trickling Filter System Pre-Filtration - Clarifiers Post-Filtration - Clarifiers Solids Handling Recirculation
TF 2.4	Organization Slide This Lesson will Look at: Testing Calculating Monitoring Correcting
TF 2.5	Summary of Operational Control Tests Needed
TF 2.6	Loading Need to Test Influent for Incoming Material
TF 2.7	Loading Test Influent for Flow, BOD and Suspended Solids
TF 2.8	Loading Test Influent for pH and Temperature
TF 2.9	Effluent Quality Test for BOD and Suspended Solids
TF 2.10	Compare D.O. in Influent and Effluent Streams to Determine Amount of Available D.O.
TF 2.11	All of the Factors have an Influence on the Biomass. The Extent of their Influence is Determined by These Corresponding Tests.
TF 2.12	Organization Slide

TF 2.13

Hydraulic Loading

- Gal/day/ft^2
- Significance
- Ranges

TF 2.14

Organic Loading

- lbs/day/ft^3
- Significance
- Ranges

TF 2.15

Recirculation Ratio

- Return Flow Divided by Influent Flow
- Significance

TF 2.16

Removal Efficiency

- Use to Assess Degree of Treatment

TF 2.17

Transition Slide

- Indicate that you will move to overhead projector or chalkboard to practice these calculations.
- Refer to overhead masters and have students work through problems.
- Work sheet could be assigned at this time.

TF 2.18

Organization Slide

TF 2.19

Monitoring

The operator must monitor closely the secondary clarifier, the trickling filter, and observe process indicators.

TF 2.20

At the Secondary Clarifier

The operator observes sludge depth and adjusts sludge pumping rate.

TF 2.21

The operator should plot and follow the trends of process indicators.

TF 2.22

At the trickling filter the operator observes the distribution of wastewater and the development of excessive growth.

TF 2.23 Through careful monitoring the operator can quickly identify problems.

TF 2.24 Organization Slide

TF 2.25 The goal of operation is to monitor the system and make corrections. The plant must be kept "flying straight and true."

TF 2.26 Influent Problems

- Fluctuating Temperatures

TF 2.27 - Toxic Influent
  - Prevent these types of materials from entering the plant.

TF 2.28 Organizational Slide

- Physical Problems

TF 2.29 Plugged Nozzles

- Uneven Distribution
- Uneven Growth
- Flush out Orifices

TF 2.30 Ponding

- Definition
- Causes

TF 2.31 Ponding Corrections

- Raking
- Hosing

TF 2.32 - Flooding
- Arm Walking

TF 2.33 - Drying
- Flushing

TF 2.34 - Chlorine Treatment - 5 mg/l
- Check Primary for Efficiency

TF 2.35 Filter Flies

TF 2.36 Filter Fly Correction

- Wash Sidewalls

TF 2.37 - Chlorine Treatment - 1 mg/l
- Insecticides

TF 2.38	Odor
TF 2.39	Odor Corrections Increase Recirculation
TF 2.40	Hose Down Media
TF 2.41	Icing
TF 2.42	Icing Conditions Decrease Recirculation
TF 2.43	Adjust Spray Nozzles Break Up and Remove Cover the Filter
TF 2.44 - 2.52	Review Slides

$$\text{SURFACE AREA}, _{FT}2 = 3.14\ R^2$$

$$\text{VOLUME}, _{FT}3 = 3.14 \quad R^2 \; H$$

$$\text{HYDRAULIC LOADING}_{,\ GPD/FT^2} = \frac{\text{FLOW, GPD}}{\text{AREA, } FT^2}$$

$$\text{ORGANIC LOADING}_{\text{LBS/DAY/1000 FT}^3} = \frac{\text{LBS BOD/DAY}}{\text{VOLUME}_{\text{1000 FT}^3}}$$

$$\text{RECIRCULATION RATIO} = \frac{\text{RECIRCULATION FLOW}}{\text{AVERAGE INFLUENT FLOW}}$$

$$\text{REMOVAL EFFICIENCY} = \frac{\text{IN} - \text{OUT}}{\text{IN}} \times 100\%$$

Answers to Worksheet

1. Calculate the surface area of a trickling filter with an 80-ft. diameter in ft^2.

$$\begin{aligned} \text{Area} &= \pi r^2 \\ &= 3.14\ (40\ ft)^2 \\ &= 5024\ ft^2 \end{aligned}$$

2. Calculate the volume in ft^3 of a 150-ft. diameter filter that is 8 ft. deep in ft^3 and 1,000 ft^3.

$$\begin{aligned} \text{Volume in } ft^3 &= \pi r^2 h \\ &= 3.14\ (75\ ft)^2\ 8\ ft \\ &= 141{,}300\ ft^3 \end{aligned}$$

$$\begin{aligned} \text{Volume in } 1{,}000\ ft^3 &= \text{Volume in } \frac{ft^3}{1{,}000} \\ &= \frac{141{,}300\ ft^3}{1{,}000} = 141 \text{ thousand } ft^3 \end{aligned}$$

3. If a trickling filter plant has an influent flow of 4.0 MGD and a total filter area of 25,000 ft^2, what is the hydraulic loading?

$$\begin{aligned} \text{Hydraulic loading} &= \frac{\text{Flow, gpd}}{\text{Area, } ft^2} \\ &= \frac{4.0\ \cancel{Mgal}}{day} \times \frac{1{,}000{,}000\ gal}{\cancel{Mgal}} \times \frac{1}{25{,}000\ ft^2} \\ &= 160\ gpd/ft^2 \end{aligned}$$

4. What is the organic loading in lbs BOD/day/1,000 ft^3 on a filter if there are 3,000 lbs/day BOD in the primary effluent and the filter has a volume of 72,000 ft^3?

$$\begin{aligned} \text{Organic loading} &= \frac{\text{lbs BOD/day}}{\text{Vol, } 1{,}000\ ft^3} \\ &= \frac{3{,}000\ \text{lbs BOD/day}}{72{,}000\ ft^3/1{,}000} \\ &= 41.7\ \text{lbs BOD/day/}1{,}000\ ft^3 \end{aligned}$$

5. If a plant influent flow meter reads 2.0 MGD and the recirculation flow is 3.0 MGD, what is the recirculation ratio?

$$\text{Recirculation Ratio} = \frac{\text{Recirculation Flow}}{\text{Average Influent Flow}}$$

$$= \frac{3.0}{2.0} = 1.5$$

6. If the primary effluent is 150 mg/l BOD and the secondary clarifier effluent is 25 mg/l BOD, what is the BOD removal efficiency for the filter?

$$\text{Removal Effluent} = \frac{\text{IN} - \text{OUT}}{\text{IN}} \times 100\%$$

$$= \frac{150 - 25}{150} \times 100\%$$

$$= 83.3\%$$

7. Plant Data:

2 filters	- each 100 ft. diameter, 7 ft. deep
Total flow	- 2 MGD (equally split)
Total recirculation flow	- 1.2 MGD
Primary effluent	- 125 mg/l BOD
Secondary effluent	- 20 mg/l BOD

Calculate: Hydraulic loading
Organic loading
Recirculation ratio
BOD removal efficiency

$$\text{Hydraulic loading} = \frac{\text{Flow, gpd}}{\text{Area, ft}^2}$$

$$= \frac{2 \text{ Mgal} \times 1{,}000{,}000 \text{ gal}}{\text{day} \times \text{Mgal} \times 2 \times 3.14 \times (50 \text{ ft})^2}$$

$$= 127 \text{ gal/day/ft}^2$$

$$\text{Organic loading} = \frac{\text{lbs BOD/day}}{\text{Vol, 1,000 ft}^3}$$

$$= \frac{125 \text{ mg/l} \times 2 \text{ MG} \times 8.34 \text{ lb}}{\frac{\text{day}}{2 \times 3.14 \times (50 \text{ ft})^2 \times 7 \text{ ft}/1{,}000} \quad \frac{\text{gal.}}{}}$$

$$= \frac{2{,}085 \text{ lbs BOD/day}}{109{,}900 \text{ ft}^3/1{,}000}$$

$$= 19.0 \text{ lbs BOD/day/1,000 ft}^3$$

$$\text{Recirculation Ratio} = \frac{\text{Recirculation Flow}}{\text{Average Influent Flow}}$$

$$= \frac{2.0}{1.2}$$

$$= 1.7$$

$$\text{Removal Effluent} = \frac{\text{IN} - \text{OUT}}{\text{IN}} \times 100\%$$

$$= \frac{125 - 20}{125} \times 100\%$$

$$= 84\%$$

TRICKLING FILTERS

Final Quiz

Name _____

Multiple Choice: Choose the one best answer and place an "X" in front of the corresponding letter.

1. The piping system that applies primary effluent evenly over the surface of the filter is the:

   _____ a. media
   _____ b. distribution system
   _____ c. underdrain system
   _____ d. ventilation system

2. The material that supports the growth of the biological mass is the:

   _____ a. media
   _____ b. distribution system
   _____ c. underdrain system
   _____ d. ventilation system

3. The piping system that collects the fluid at the bottom of the filter is the:

   _____ a. media
   _____ b. distribution system
   _____ c. underdrain system
   _____ d. ventilation system

4. The passageways that provide for aerobic growth conditions by bringing air into contact with the microorganisms is the:

   _____ a. media
   _____ b. distribution system
   _____ c. underdrain system
   _____ d. ventilation system

5. A 6 to 10 foot deep filter with hydraulic loadings in the range of 25-100 gal/day/ft^2 and organic loadings of 5-23 lbs BOD/day/1,000 ft^3 is termed:

   _____ a. a standard rate filter
   _____ b. a high rate filter
   _____ c. a roughing filter

6. Operating with an organic loading greater than 15 lbs BOD/day/1,000 ft^3 is called a:

   _____ a. standard rate filter
   _____ b. high rate filter
   _____ c. roughing filter

7. Which of the following would not usually be found in a trickling filter?

_____ a. bacteria

_____ b. protozoa

_____ c. flies

_____ d. snails

_____ e. fish

8. The biomass of a trickling filter requires carbon, nitrogen and phosphorus with the carbon to nitrogen ratio being:

_____ a. 1:1

_____ b. 5:1

_____ c. 10:1

_____ d. 20:1

_____ e. 100:1

9. Although carbon is the normal limiting factor in normal domestic wastewater, industrial wastes may be limited in:

_____ a. carbon

_____ b. oxygen

_____ c. nitrogen

_____ d. potassium

_____ e. hydrogen

10. The rate of growth of microorganisms on the filter is affected by:

_____ a. organic material only

_____ b. BOD and temperature

_____ c. the recirculation ratio

_____ d. the hydraulic loading

_____ e. none of the above

11. Which of the following occurs during the biomass growth cycle?

_____ a. a layer of organisms develop with aerobic organisms next to the media and anaerobic organisms on the outside.

_____ b. liquid carries oxygen down to the biomass while BOD is supplied through the ventilation system.

_____ c. sloughing occurs intermittently as hungry microorganisms lose their grip on the media

_____ d. sloughing occurs every fall because of heavy rains

_____ e. all of the above

12. Which of the following tests is not routinely performed by the operator of a trickling filter?

_____ a. BOD
_____ b. suspended solids
_____ c. volatile acids
_____ d. temperature
_____ e. pH

13. If the flow over a filter is 4 MGD and the surface area is 10,000 ft^2, what is the hydraulic loading?

_____ a. 40 gpd/ft^2
_____ b. 400 gpd/ft^2
_____ c. 2,500 MGD/ft^2
_____ d. 0.4 gpd/ft^2
_____ e. none of the above

14. If a filter is 75 ft. in diameter and 6 ft. deep with a loading of 200 mg/l BOD and a flow of 0.6 MGD, what is the organic loading?

_____ a. 1,000 $lbs/day/1,000\ ft^3$
_____ b. 26 $lbs/day/1,000\ ft^3$
_____ c. 38 $lbs/day/1,000\ ft^3$
_____ d. 0.04 $lbs/day/1,000\ ft^3$
_____ e. 9.4 $lbs/day/1,000\ ft^3$

15. Filter flies can be controlled by:

_____ a. dose with 5 mg/l chlorine for a few hours each day.
_____ b. keep the walls wet by opening ends of distribution arms.
_____ c. apply insecticide to walls.
_____ d. a and c above
_____ e. b and c above

16. If high effluent suspended solids occur, the following should be checked:

_____ a. is filter hydraulically overloaded?
_____ b. is there a high organic load?
_____ c. is clarifier equipment operating correctly?
_____ d. a and b above
_____ e. all of the above

17. If high influent flow upsets treatment:

_____ a. reduce recirculation

_____ b. operate staged filters in series

_____ c. increase in-plant side streams

_____ d. adjust distribution nozzles

_____ e. all of the above

18. If BOD reduction is falling but suspended solids removal is okay, check for:

_____ a. high temperature influent

_____ b. toxic loadings

_____ c. low influent BOD

_____ d. icing

_____ e. clarifier malfunction

19. Ponding may be corrected by:

_____ a. dosing with 1 mg/l chlorine for two hours

_____ b. speeding up the distribution arms

_____ c. increasing recirculation rate

_____ d. flooding the filter for one week

_____ e. all of the above

20. If odors start to be a problem around a trickling filter, check:

_____ a. vent pipes to be sure ventilation is adequate

_____ b. for excessive biological growth

_____ c. for slime growths and debris around filter

_____ d. influent conditions for high organics or H_2S

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TRICKLING FILTERS

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__X__ e. b and c above

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_____ c. for slime growths and debris around filter

_____ d. influent conditions for high organics or H_2S

X e. all of the above